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Biodynamic Loading in Orthopaedic Tissue Engineering

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1 Introduction

The objective of this work was to employ the novel design of the BioDynamic testing platform to evaluate the mechanical properties of tissue-engineered bone constructs. The testing platform allows for continuous test and stimulation in a fully integrated and instrumented configuration by providing material characterization within a physiological environment.

2 Materials and Methods

The dynamic mechanical properties of osteoblast-seeded polyurethane constructs were evaluated with our unique computer-controlled moving magnet linear motor that provides load, displacement, strain or pressure profiles. The cylindrical polyurethane scaffolds were 10 mm in diameter and 10 mm in height, and each scaffold was seeded with 250,000 MLO-A52 cells. Dynamic loading was performed in compression at 1 Hz frequency and 5% strain for 2 hours every 2 days in an orthopaedic BioDynamic chamber mounted on an ElectroForce 3200 instrument. MC3T3-E1 cells seeded in a laboratory-synthesized polyurethane foam were also evaluated, and cellular metabolic activity and different loading regimes were studied.

3 Results

The ability to perform low force compressive loading is illustrated in **Fig. 1**. The Young's modulus of the loaded constructs increased significantly over the culture period (**Fig. 2**) and was supported by a 40% increase in collagen deposition (**Fig. 3**) compared to unloaded samples as quantified by colorimetric analysis.

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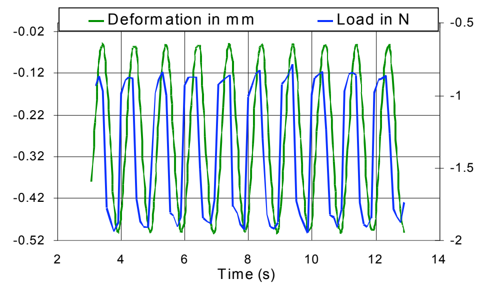

Figure 1 : Load and displacement traces for a polyurethane-based bone construct.

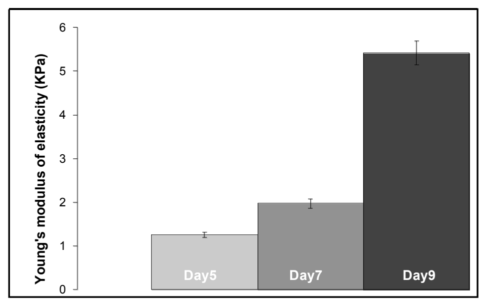

Figure 2 : Young's modulus of loaded-constructs as a function of culture time.

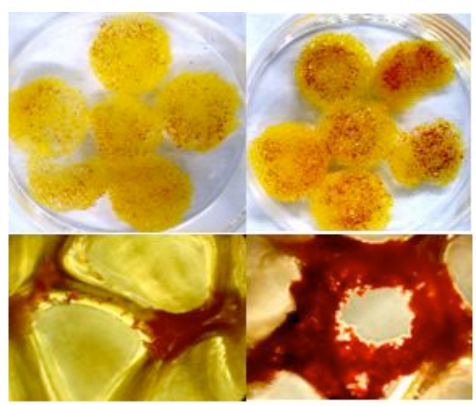

Figure 3 : Sirius red staining for collagen (red) shows more collagen deposition in the mechanically loaded (right panels) compared to the unloaded (left panels) samples.

4 Conclusion

The data obtained with the polyurethane-based constructs show that the BioDynamic instrument is suitable for evaluating the dynamic properties of orthopaedic tissue-engineered constructs in a sterile environment that supports long term mechanical property characterization and tissue stimulation.